

# **MANUAL FOR CONTINUOUS DESCENT OPERATIONS**

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## **EXECUTIVE SUMMARY**

This Manual contains guidance material on the airspace design, instrument flight procedures, ATC facilitation and flight techniques necessary to enable Continuous Descent (CD) profiles. It therefore provides background and implementation considerations for:

- a) Airspace and procedure designers,
- b) Air traffic managers and controllers,
- c) Service providers (Airports and Air Navigation Service Providers (ANSP))
- d) Pilots.

Key objectives of this manual are to improve the:

- a) overall management of traffic and airspace in order to enable uninterrupted continuous descents, without disrupting departures,
- b) understanding of continuous descent procedures and profiles, and
- c) harmonization and standardization of associated terminology.

Continuous Descent is one of several tools available to aircraft operators and ANSPs to reduce noise, fuel burn and the emission of greenhouse gases. Over the years, different route models have been developed to facilitate CDs and several attempts have been made to strike a balance between the ideal of environmentally friendly procedures and the requirements of a specific airport or airspace.

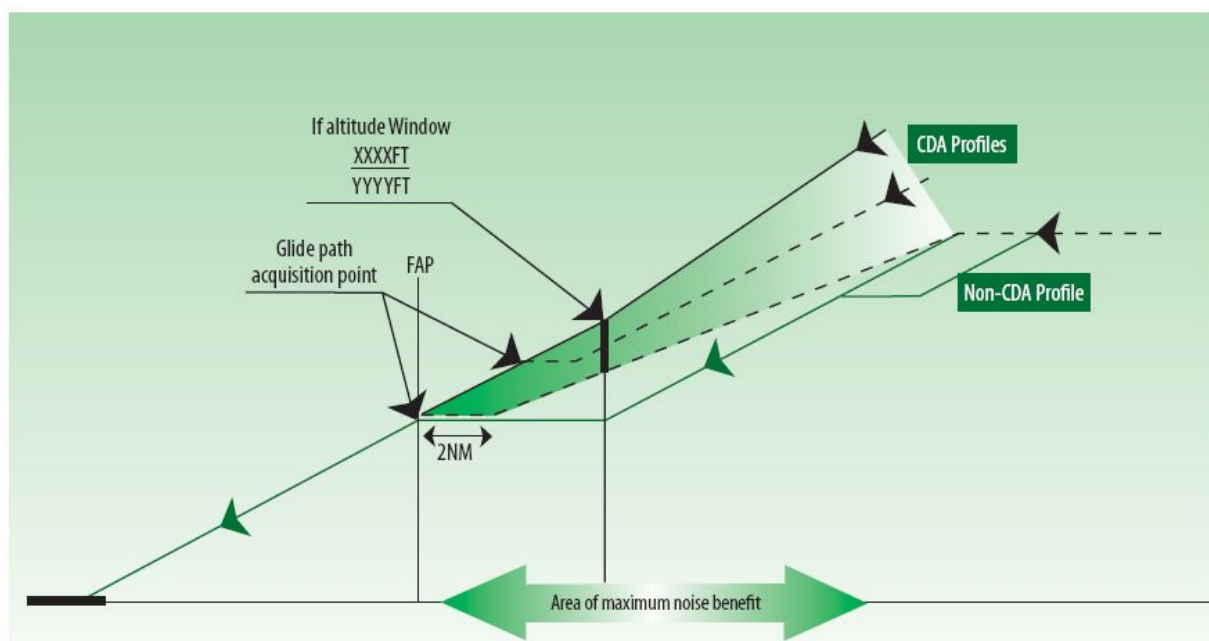
Future developments in this field are expected to allow different means of realising the performance potential of CD without compromising the optimal Airport Arrival Rate (AAR). The core CD definition and the concept at the heart of this manual will also apply to these increasingly sophisticated methods of facilitating CD operations.

Terminology and procedural standardisation is important for flight safety. From the pilots' and air traffic controllers' perspective, flight procedures and pilot communications should be unambiguous. For the procedure designer, it is important to understand the flight characteristics, limitations and capabilities of aircraft expected to perform CDs, as well as the characteristics of the airspace and routes where it will be used. For airport operators and environmental entities, it is important to understand, the extent and limitations of environmental benefits aircraft performance and airspace limitations when proposing to introduce CD operations.

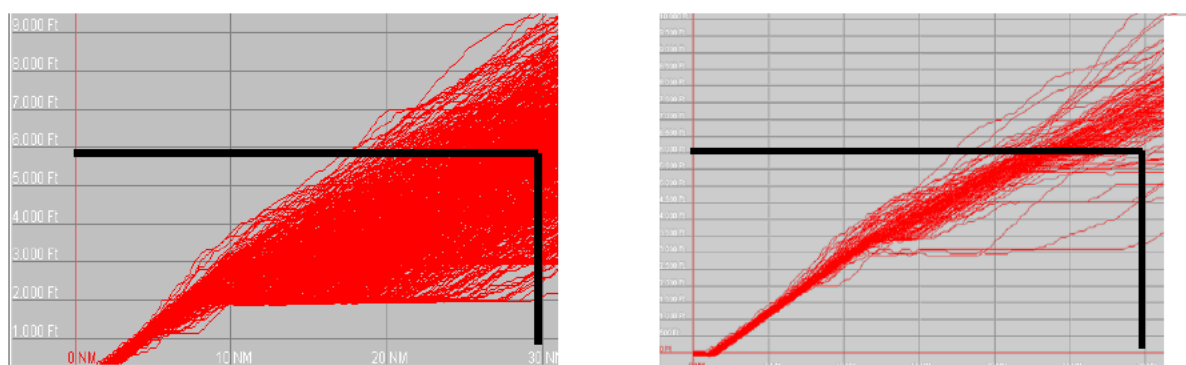
Considering the high cost of fuel and growing concerns about the environment and climate change, collaborating to facilitate CDs is an operational imperative where all stakeholders benefit.

Maintenance of safety during all phases of flight is paramount - nothing in this guidance shall take precedence over the requirement for safe operation and control of aircraft at all times. For the avoidance of doubt, all recommendations are to be read as "subject to the requirements of safety".

Before any CD trials or operations commence, the proposed implementation should be the subject of a local safety assessment.



**Fig 1...: Schematic principle of CD**



**Fig. 2: Typical vertical approach profiles without (left) and with (right) CD**

## **DEFINITIONS AND EXPLANATIONS OF TERMS**

**Continuous Descent (CD):** A aircraft operating technique, enabled by airspace design, procedure design and ATC facilitation, in which an arriving aircraft continuously descends by employing minimum engine thrust, ideally in a low drag configuration, prior to the Final Approach Fix (FAF)/Final Approach Point (FAP).

*Note: An optimum CD starts from the Top of Descent and uses descent profiles that reduce noise, fuel burn and emissions.*

As noted in the definition, and to achieve the maximum reduction in fuel burn, noise, and emissions, a CD should be initiated from the highest possible altitude in the enroute or terminal airspace structure. Where the need exists to distinguish between “arrival” and “approach” segments, the arrival segment can be considered to extend from the en-route structure until the IAF, while the approach descriptor applies in the terminal area from the IAF until or before the FAF/FAP).

CD should not be confused with CDFA which has a separate definition, is related to a different phase of flight. CDFA is addressed in PANS-OPS Vol I:

**Continuous descent final approach (CDFA):** A technique, consistent with stabilized approach procedures, for flying the final approach segment of a non-precision instrument approach procedure as a continuous descent, without level-off, from an altitude/height at or above the final approach fix altitude/height to a point approximately 15 m (50 ft) above the landing runway threshold or the point where the flare maneuver should begin for the type of aircraft flown.

*Note: The CDFA technique simplifies the final segment of the non-precision approach by incorporating techniques similar to those used when flying a precision or APV approach procedure. The CDFA technique improves pilot situational awareness, and is entirely consistent with all “stabilized approach” criteria.*

**Optimized Profile Descent (OPD):** A form of CD operations where a descent profile is comprised of idle-power performance descent profile segments and geometric descent profile segments that maximize altitude, minimize the thrust required to remain on the path, terminates the path at the desired end location and satisfy the altitude and speed constraints along the path.

**ABBREVIATIONS**

AIP	Aeronautical Information Publication
AAR	Airport Arrival Rate
ATC	Air Traffic Control
CD	Continuous Descent
CIG	CD Implementation Group
DTG	Distance To Go (Distance from Touchdown)
DTW	Downwind Termination Waypoint
FMS	Flight Management System
ICAO	International Civil Aviation Organisation
QNH	Barometric pressure setting to give altitude above mean sea level
RNAV	Area Navigation
SEL	Sound Exposure Level in decibels (dB) ( <i>see note</i> )
SID	Standard Instrument Departure
STAR	Standard Arrival Route
TOD	Top of Descent

*Note: SEL is used to describe the amount of noise from an event such as an individual aircraft flyover. As the decibel scale for denoting sound energy is logarithmic, a change of  $\pm 3\text{dB}$  equates to a halving or doubling of sound energy.*

## 1 INTRODUCTION

### 1.1 PURPOSE

The purpose of this Manual is to standardize and harmonize the development and implementation of CD operations. To achieve this airspace and instrument flight procedure design and ATC techniques should all be employed in a cohesive manner. This will then facilitate the ability of flight crews to use in-flight techniques to reduce the overall environmental footprint and increase the efficiency of commercial aviation. These CD operations are variously known as Continuous Descent Arrivals, Continuous Descent Approaches, Optimized Profile Descents, Tailored Arrivals, 3D Path Arrival Management, Business Trajectories, etc. All are customized to decrease the overall noise and carbon emissions in the local operating environment.

The information in this Manual is intended to support collaboration among the different stakeholders involved in implementing these Continuous Descents:

- a) Aircraft operators and pilots
- b) Air Navigation Service Providers including controllers
- c) Instrument Flight Procedure designers
- d) Airport Operators.

### 1.2 FACILITATING CD OPERATIONS

In general, air traffic flow managers, working with air traffic sequencing, controllers manage arriving aircraft as efficiently as possible, within the constraints of their safety and expediting responsibilities. However, “efficiency” can have different meanings and may vary depending on traffic demand, aircraft mix, or weather. To achieve overall arrival and departure efficiency, a balance should be struck between airport capacity, flight time, distance, fuel burn, emissions and noise. Such decisions will often be strongly influenced by local, national or regional policies. Environmental impact is now a significant issue for aviation in general and should be considered both when designing airspace and instrument flight procedures, and when managing the air traffic operation.

Specifically, techniques that enable a fuel-efficient (minimum thrust), optimum descent and approach should be used wherever and whenever possible. The total energy of the aircraft at high altitude can be used most efficiently during descent with minimum thrust and drag. However, the pilot should have the maximum flexibility to manage the aircraft's speed and rate of descent. Examples of facilitating CDs include the provision of distance to go information under radar vectors, thereby enabling a pilot to manually adjust his rate of descent. Alternatively, for aircraft equipped with Flight Management Systems, an optimized descent could be planned, prior to Top of Descent, and executed in coordination with Air Traffic, using a fixed lateral flight path stored in, or datalinked to, the aircraft navigation database. A mixture of these two methods could also be applied.

Fixing a lateral flight path and allowing the aircraft flexibility in the vertical plane may deprive the air traffic controllers of a tool to manage their traffic separation responsibilities. For optimum traffic handling in busy periods, high capacity airports, air traffic controllers presently use tactical intervention, that is radar vectoring and/or speed control, to sequence and separate aircraft. A published arrival route, stored in the navigation database, may be there for the purpose of communication or radar failure only. The air traffic controller expeditiously sequences aircraft prior to the final approach utilising the lateral plane to, for example, extend, shorten or laterally modify the flight path. The vertical plane is used to separate incoming from outgoing traffic and for sequencing and simplification purposes: the traffic operating in a three dimensional airspace climbing and descending is difficult to comprehend where many aircraft are involved. Horizontal separation and standardized procedures simplify the traffic handling.

The benefits of CD operations may be adversely affected by such additional separation and sequencing techniques which should be minimized to the extent practical. However, when ATC loses the flexibility to use all tools to sequence and manage arrival flows, there is a risk that capacity and efficiency will suffer. Longer CD operations, that do not adversely affect the optimal Aerodrome Arrival Rate (AAR), can be achieved with early sequencing, but this depends upon local conditions and the availability of suitable controller and pilot tools.

It is recognised that optimizing descent profiles throughout the descent from cruise altitude can reduce fuel burn, emissions and noise. Different methods can be employed to achieve the target of CD operations while maintaining the optimal AAR.

This Manual provides background information and guidance, including a concept of operation, necessary for aviation stakeholders to standardize and harmonize the implementation of a continuous descent operation. Use of this guidance material should minimize the proliferation of different continuous descent designs, and should enhance safety by procedural standardization. Further updates to this manual are expected when advanced supporting tools to further optimise CD are matured.

### 1.3 CONCEPTS OF OPERATION

In the ICAO PBN Manual (Doc 9613), the following general statement related to the airspace concept has been given:

*An airspace concept may be viewed as a general vision or a master plan for a particular airspace. Based on particular principles, an airspace concept is geared towards specific objectives. Airspace concepts need to include a certain level of detail if changes are to be introduced within an airspace. Details could explain, for example, airspace organization and management and the roles to be played by various stakeholders and airspace users. Airspace concepts may also describe the different roles and responsibilities, mechanisms used and the relationships between people and machines.*



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A CD can enable one, or more, of the several specific strategic objectives and, as such, is part of the general vision of the airspace concept (see Figure A-2-1 out of the PBN Manual) in the environmental area. Objectives are usually identified by Airspace Users, ANSPs, Airport Operators as well as by government policy. In the case of the environmental protection, it includes Local Communities, Planning Authorities and Local Government. It is the function of the airspace concept and the concept of operations to respond to these requirements in a balanced, forward-looking manner. The PBN manual Implementation chapter details the need for an effective collaboration among these entities.

The strategic objectives which most commonly drive airspace concepts are:

- a) safety,
- b) capacity,
- c) efficiency,
- d) access; and
- e) environment.

For an environmental policy, there are several considerations which may drive the decisions. The environmental goal can be noise abatement, increased fuel efficiency and, hence, reduced emissions, or some combination of these. This applies to both arrivals and departures. A CD design must accommodate departures, where uninterrupted climb is the most fuel efficient and lateral avoidance of populated areas, more accurate route following and dedicated take-off techniques can be used for noise alleviation (close to or further from an airport) (refer to PANS-OPS Vol I Part I Section 7).

CD enables a more efficient fuel burn profile and reduced emissions from the Top of Descent, together with improved noise abatement during the Initial and/or intermediate approach phases of flight. This is separate from the efficiencies that can be realised through direct routing and noise-preferential routes.

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In particular, the application of CD operations may have a serious impact on any strategy to maintain capacity. The aim should therefore be to maximise CD operations and not adversely affect AAR. CD operations may be enhanced by the use of specialist ATM tools for separation, sequencing and metering. Arriving and departing traffic are interdependent and CD from Top of Descent should not be designed or implemented such that they disadvantage other descending aircraft or aircraft in other phases of flight. Balancing the demands of capacity, efficiency, access and the environment is one of the most demanding tasks when developing an airspace definition.

### **Extract from ICAO Doc9613**

***Safety:*** The design of RNP instrument approach procedures could be a way of increasing safety (by reducing Controlled Flights into Terrain (CFIT)).

***Capacity:*** Planning the addition of an extra runway at an airport to increase capacity will trigger a change to the airspace concept (new approaches to SIDs and STAR required).

***Efficiency:*** A user requirement to optimize flight profiles on departure and arrival could make flights more efficient in terms of fuel burn.

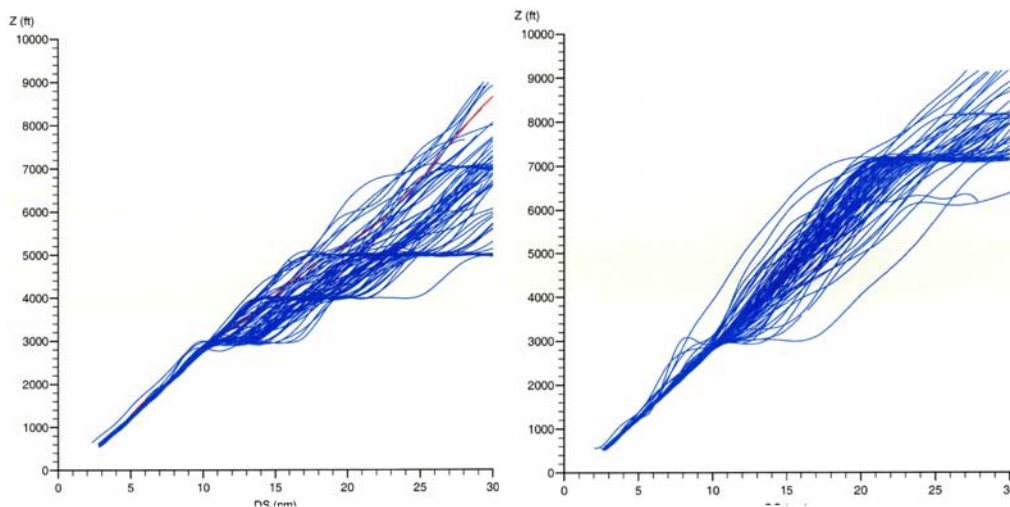
***Access:*** A requirement to provide an approach with lower minima than supported by conventional procedures, to ensure continued access to the airport during bad weather, may result in providing an RNP approach to that runway.

***Environment:*** Requirements for reduced fuel use and emissions, noise preferential routes, specific Take-off techniques or continuous descent/arrivals/approaches (CDA), are environmental motivators for change.

## 2

## CONTINUOUS DESCENT OPERATIONS

A CD is an ATC facilitated aircraft operating technique designed to reduce noise on the ground, fuel burn and emissions through increased flight altitudes, low engine thrust settings and a low drag configuration. The optimum vertical profile takes the form of a continuously descending path with minimum level segments only as needed to decelerate and configure the aircraft. The vertical angle actually flown is generally not fixed, but is determined by the actual performance of the aircraft and atmospheric conditions. A CD can be flown with or without the support of a computer-generated vertical flight path (VNAV function of the Flight Management Computer), and with or without a fixed lateral path. Using a computer-generated vertical path over a fixed lateral path will result in the greatest level of benefit and ease of operation. The optimum vertical path angle will vary depending on the type of aircraft, its actual weight, the wind, air temperature, atmospheric pressure and icing conditions, and other dynamic considerations.

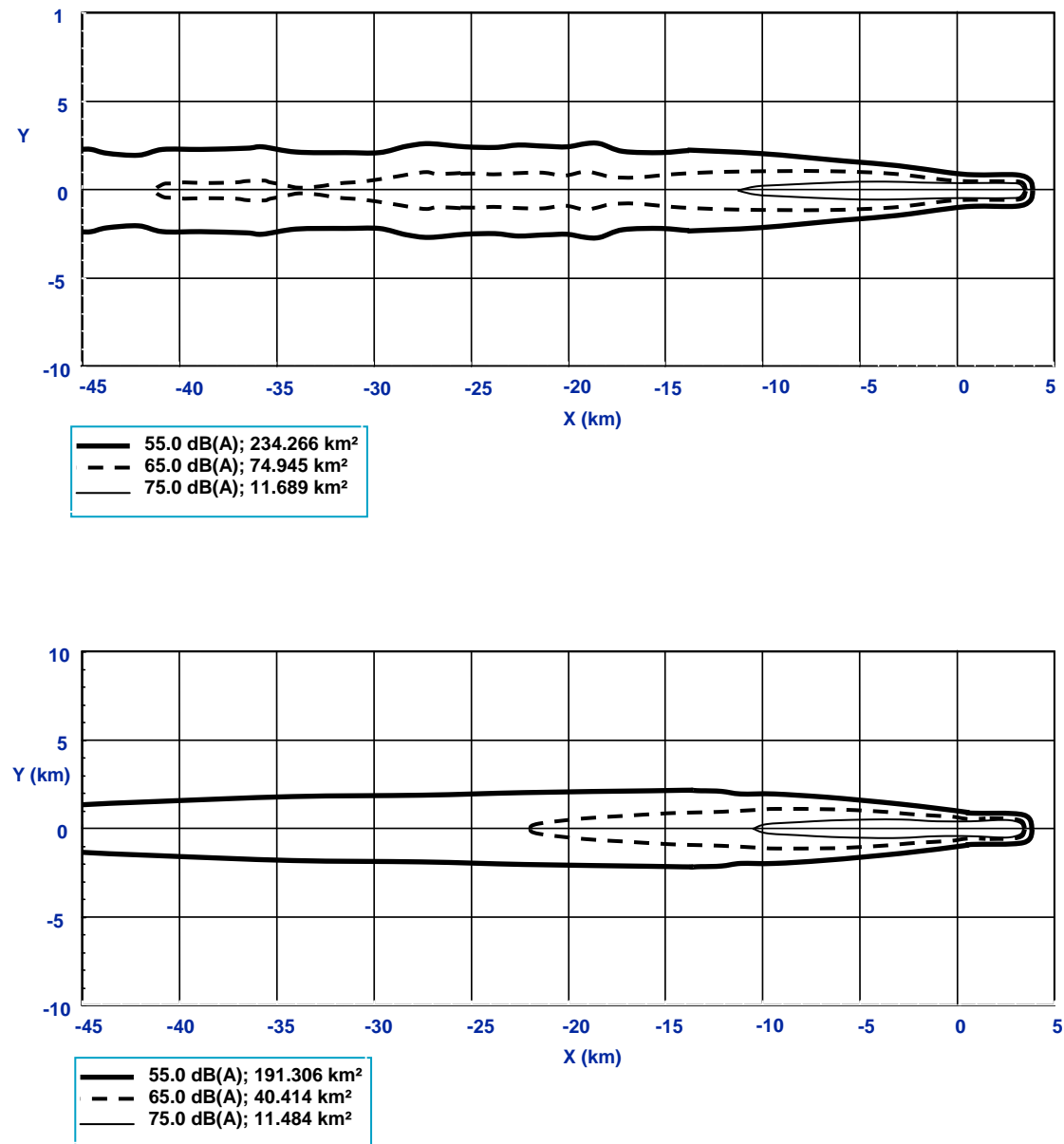


**Fig. 3: Typical Approach phase profiles without (left) and with (right) CD**

Application of a CD operation has implications for total airspace design. Unless carefully designed, CD could conflict with departing traffic streams and this must be avoided. When assessing the positive effects of a CD on noise levels, fuel burn, and emissions, the overall impact on all air traffic in the terminal area and adjacent airspace should be taken into account. If, for example, departing or enroute aircraft are kept at lower altitudes for longer, the positive effects of CD may be reduced or negated.

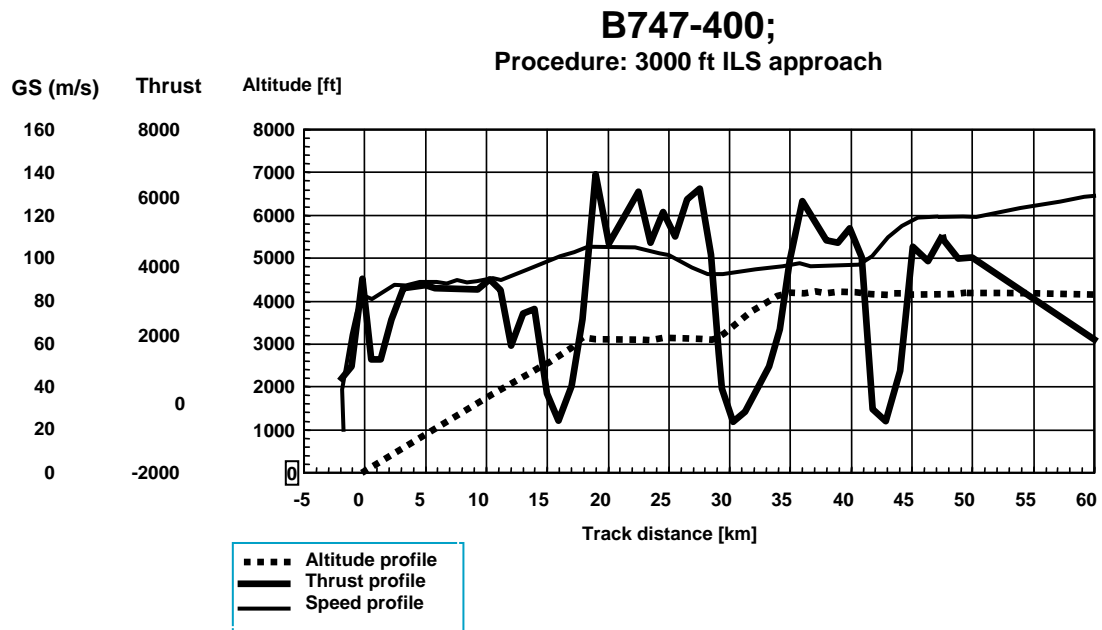
Continuous Descents provide environmental and economic benefits in **three key areas:**

- a) **Less noise** at intermediate distances (10-30 NM) from the runway. Maximum noise reduction is typically achieved under the flight path prior to glide slope intercept. This may be in an area over 10 NM from the runway and outside the area normally considered in noise consultations.

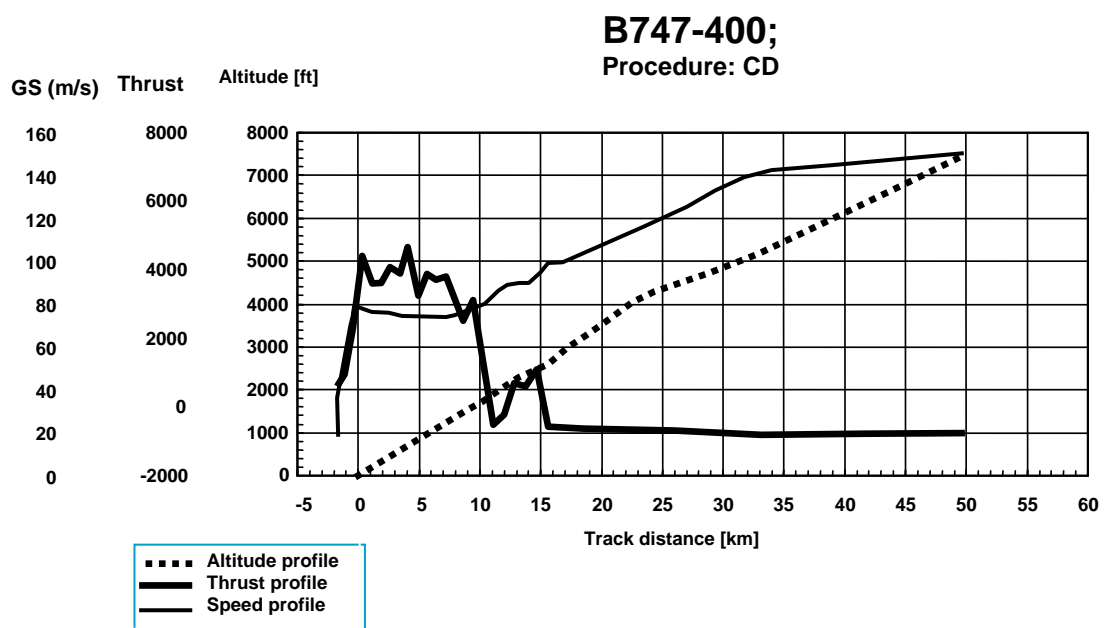


**Fig. 4 Effect CD profile on noise footprint**

- b) Lower emissions. Reductions in emissions can lead to reduced CO<sub>2</sub> charges, in the event of an introduction of an emissions trading system.
- c) Reduced fuel burn. Reduced fuel burn depends on many factors: most importantly, the length of the path where low thrust settings can be used. The maximum benefit is achieved by keeping the aircraft as high as possible until it reaches the optimum descent point as determined by the onboard flight management computer, or for less equipped aircraft, by a ground based trajectory predictor. The ideal CD operation starts from the Top of Descent.



**Fig. 5: typical non CD performance characteristics**



**Fig. 6: typical CD performance characteristics**

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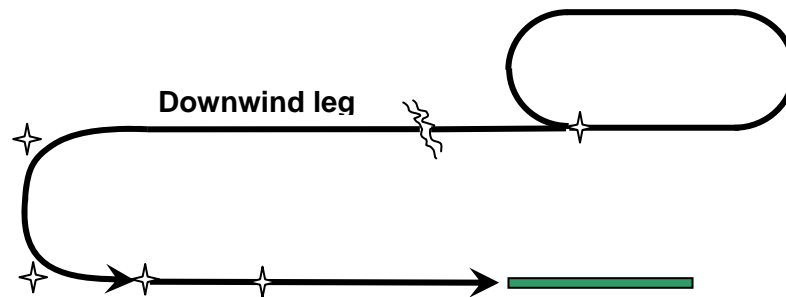
CD can provide benefits through reduction in noise, fuel burn and emissions. However, facilitating CD can require tradeoffs, potentially reducing capacity and delaying other aircraft. CD should be considered as “the art of the possible”. The aim is to achieve the optimum CD in terms of number of aircraft accommodated and the extent of CD enabled for each flight.

A CD operation reduces fuel burn, noise and emissions by enabling:

- a) minimum thrust-setting for the conditions during descent;
- b) minimum drag for phase of flight<sup>1</sup>; and
- c) increased height of the flight path (staying higher longer, as permitted by ATC)

There are a number of options available to the procedure designer and ATC facilitator when developing a CD concept of operations:

- a) Holding – Aircraft may be cleared for CD upon leaving a hold.

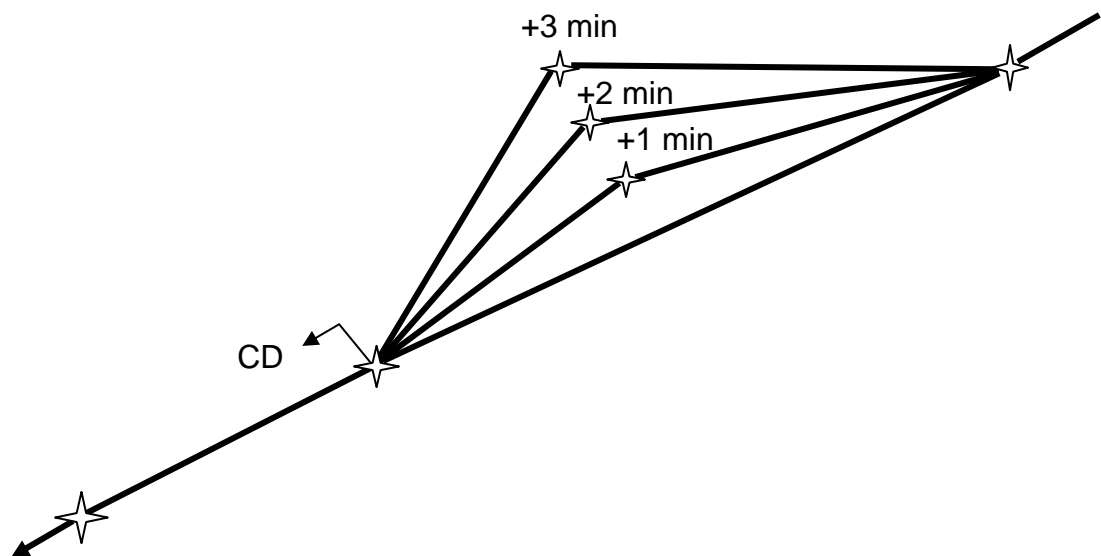


**Fig.6: Holding as sequencing tool facilitating CD Operation**

- b) Path stretching – Prior to Top of Descent, a revised lateral path may be co-ordinated with the aircraft. Alternatively, when the aircraft is established on the downwind, this may be extended by radar vectoring or by lateral path revision (“Direct To” to waypoint) – known as ‘Hybrid Model’ and discussed in more detail below.

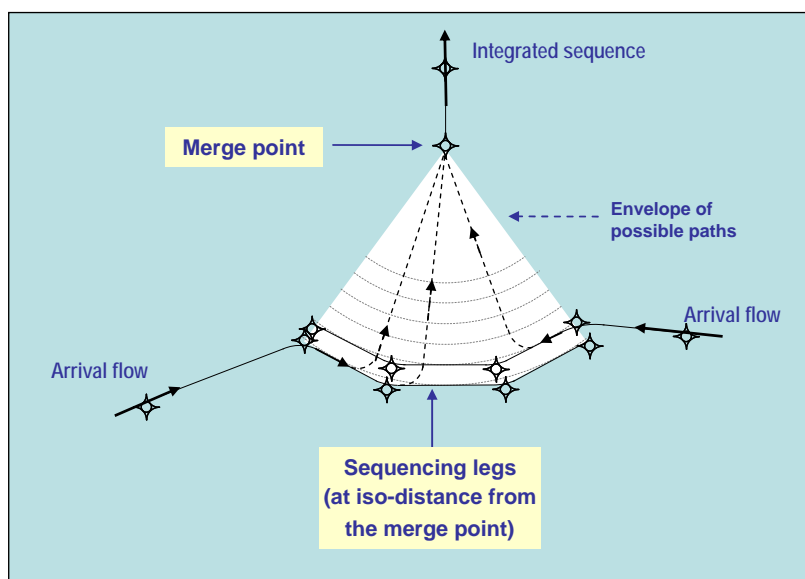
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<sup>1</sup> Use of drag can outweigh the effect of engine noise.



**Fig.7: example of Path stretching system**

- c) Speed control – Prior to Top of Descent or during descent in order to improve sequencing and merging.
- d) Point Merge - See the illustration below. With this technique, aircraft follow an RNAV routing, which generally includes a level arc segment, until receiving a 'direct to' vector to a merge point. The pilot may execute a CD prior to the Point Merge arc, maintain level flight whilst following the arc and continue with CD when cleared to the merge point. When traffic permits, the aircraft is cleared direct to the merge point before establishing on the arc.



**Fig. 8: example of a Point Merge System**

There are three different options for constructing and/or executing a CD procedure:

- a) A continuous descent embedded in a published STAR, Initial Approach or other form of pre-defined flight path;

Where use is made of a published STAR or Initial Approach, the routing, with altitude constraints, should be stored in a navigation database. This allows for optimum use of the vertical and lateral navigation functions (VNAV and LNAV) of the FMC. The VNAV path will be calculated based on the latest known data in the FMC. The vertical path can be further optimised by entering additional data into the FMC, such as updated winds and, if relevant, the transition level.

- **Strengths**

- Accurate lateral flight path and therefore less lateral noise dispersion
- Highly predictable lateral flight path
- Most optimum CD profile and maximum use of on board navigation system
- Lead the way to further future automation capabilities

- **Weaknesses**

- Without supporting tools (ground and/or on board) AAR may be affected

- b) A continuous descent facilitated by ATC using radar vectors and providing distance to the runway threshold;

Where radar vectors are applied instead of a fixed lateral flight path, ATC can provide the approximate flight track-miles to the runway threshold. It is assumed that the pilot will use this information to determine the optimum descent initiation point or vertical profile to achieve the CD, typically based on a 3 degree descent angle in the terminal area. In this case, it is essential that the clearance phraseology is unambiguous and permits the pilot to maintain the last assigned flight level/altitude until it is necessary to descend on the CD as determined by the FMC or approximated by the pilot. A 3 degree descent equates to approximately 300 feet per nautical mile.

- **Strengths**

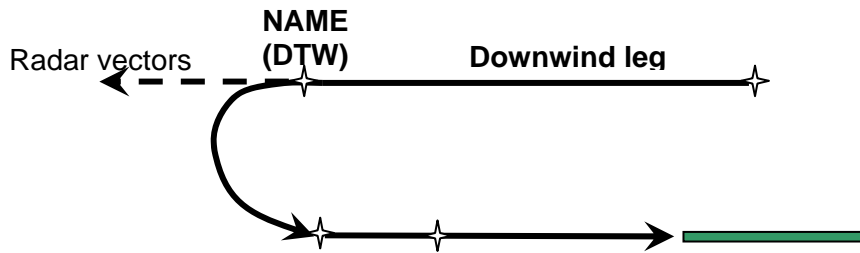
- Less accurate and less predictable lateral flight path and therefore more lateral noise dispersion
- CD profile less precise
- Possible horizontal segment in the intermediate segment
- Can be seen as initial step towards CD use

- **Weaknesses**

- Dedicated ATC skill required
- AAR may not be affected, depending on ATC skills and traffic mix/demand
- No use of on-board navigation capability
- Highly Human Factor driven system, low automation capability



- c) A hybrid of the two designs above. The hybrid option can have an open or closed downwind leg.



**Fig. 9: Hybrid design. Closed (— ) or open (···· )**

In case of the hybrid CD procedure (fixed or partly open), the route is normally published emulating the standard radar-vectoring route in order to limit flight track changes in the area around the airport. The end of the downwind leg may be marked by a waypoint, which is designated as the Downwind Termination Waypoint (DTW). The DTW can be stored in the navigation database with a base-leg turn towards the final approach intercept, or may be left open with a heading to fly for radar vectors. In the case of the latter, the pilot continues on the downwind leg until instructed by ATC to turn. ATC ensures aircraft on the opposite downwind leg are separated in case of communication failure.

ATC controls the sequencing process by extending the downwind leg on a tactical basis. This may result in an extended level segment and a lateral spread of the flight path and should therefore be seen as a sub-optimal CD application. The open CD procedure design allows for a higher capacity, but the tactical base leg creates a spread of the flight paths at low altitude. There are two methods to reduce the noise at this part of the route. One is to increase the height of the Downwind Termination Waypoint to above the final approach intercept altitude, thus requiring a descending base leg. The second and more optimum solution is a closed CD procedure, where the base leg is part of the stored route. However, a closed CD may impact capacity if the aircraft are of widely differing performance characteristics or if there is a need to integrate non-CD aircraft (i.e. lower performance) aircraft. Ultimately, the base leg can be closed while maintaining a high runway capacity, when decision support tools are used to sequence aircraft or to exchange data between the aircraft flight management system and the ground.

- **Strengths**

- Partly accurate lateral flight path and therefore less lateral noise dispersion, but dispersion at the lower end, where vectoring takes place
- Predictable lateral flight path until the downwind leg segment, where uncertainty exists over the length of the path to be flown
- On board navigation system can be used to a great extent and CD profile can be optimized
- AAR can be accommodated to a great extent

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- Flexible use of CD possible: low traffic periods and/or during night time
- **Weaknesses**
  - Flight path dispersion at low level, where noise may play an important role
  - Less optimum CD profile at the low end

CD operations should not be designed or implemented such that they conflict with the optimal AAR which maximises the use of runway capacity. There are many factors influencing the impact of CD operations on airport/runway capacity - whether the lateral guidance is from a fixed route or radar vectors, whether the fixed route is short or long, open or closed. Additional tools for ATC to manage the spacing and sequencing process may increase the AAR achieved with CD operations. Use of CD should not be designed or implemented such that they affect other non-CD, overflying, or departing traffic.

As a step by step implementation strategy, CD can be used at times with low traffic demand. During night time, when the optimal AAR is often lower, CD can be used more easily and effectively, and from greater altitude.. A subsequent step towards widespread implementation of CD could come during the day time when demand is low. The effect of the change-over between periods with and without the use of CD should be addressed as part of a safety assessment.

There is an expectation that future ground automation systems in conjunction with improvements in aircraft systems and flight procedures will enable full implementation of CD during peak traffic periods. The main element in this development in relation to the maintenance of the optimal AAR is the capability to sequence and merge the incoming traffic efficiently, prior to the initiation point of the CD. The higher the altitude/flight level at which CDs are attempted or initiated, the greater the demands on the supporting tools.

The length of the flight path needed for facilitating continuous descents from cruise flight levels may require the ATC centre controlling at the top of descent to coordinate with the adjacent centre(s). Ultimately, CD operations may take the form of flexible trajectory negotiations based on data communication exchanges between the ground and airborne systems and between aircraft. Research is under way to develop tools for managing the traffic at high demand while facilitating CD. These may include ground-based trajectory predictors and ADS-B/ASAS. In the meantime, publication of standard terminal arrival routes with efficiently defined lateral paths and flexible descent profiles designed with “windows” to accommodate crossing traffic will allow the aviation community to realize most of the operational and environmental benefits of CDs.

*Note: it may be possible that this can take place through a Adjacent Center Metering portion of the Traffic Management Advisor (TMA) tool.*

### **3 SPECIFIC STAKEHOLDER ISSUES**

#### **3.1 PROCEDURE DESIGN**

*Refer to PANS-OPS Volume II for more details.*

##### **3.1.1 General**

To the extent possible, a CD procedure should be designed with the following in mind:

- a) A low-power performance descent path segment is the path that results from a minimum thrust power setting on all engines for a given aircraft configuration, weight and atmospheric conditions. The performance descent path angle will vary with respect to the ground reference<sup>2</sup>.
- b) Altitude constraints should not be used to overly-constrain the CD path. Rather, the path should result from a clearly defined end point and those constraints necessary to meet the restrictions derived from the airspace concept and design. Minimum, maximum or altitude crossing blocks should be used whenever possible instead of hard constraints. This reduces workload for manual CD execution, and allows for minimum thrust descents.
- c) Aircraft operating limitations will also act as constraints on the CD path. In the context of normal operations, descent is followed by approach and landing. The configuration and operating conditions will introduce constraints that should be taken into account in the procedure design, even if they are not explicitly included as part of a clearance or specified as an airspace requirement.

##### **3.1.2 Collaboration and Standardisation.**

Design of CD procedures and the airspace needed to facilitate them should be a collaborative process involving the ANSP, Aircraft Operators, Airport Operators, the regulator, and through appropriate channels, environmental entities, as necessary.

Expertise in Flight Management System performance and flight procedure coding conventions should be included on the design team because the arrival procedures will be stored in a navigation database. Specifically when demanding lateral manoeuvring is involved, there may be a need for prior consultation with navigation database specialists.

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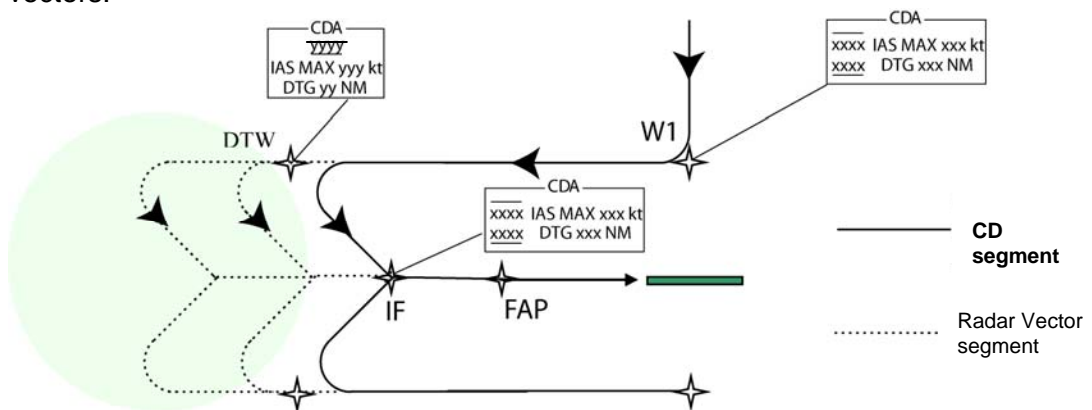
a) <sup>2</sup> Use of a geometric descent path is seen as a possible future option. A geometric descent path segment is a fixed angle descent path with respect to the ground reference. It will likely not be a minimum-power descent path for a given aircraft weight, configuration and atmospheric conditions; additional thrust or drag may be required to keep the aircraft on the geometric path. Geometric descent path segments may result due to altitude or speed constraints along the path.

As in all instrument flight procedures, the design should be standardised and should conform to accepted charting and database conventions in order to support the standardisation of cockpit procedures.

### 3.1.3 CD Options.

To implement a CD to an airport, it is necessary to identify which of the following airport traffic scenarios apply:

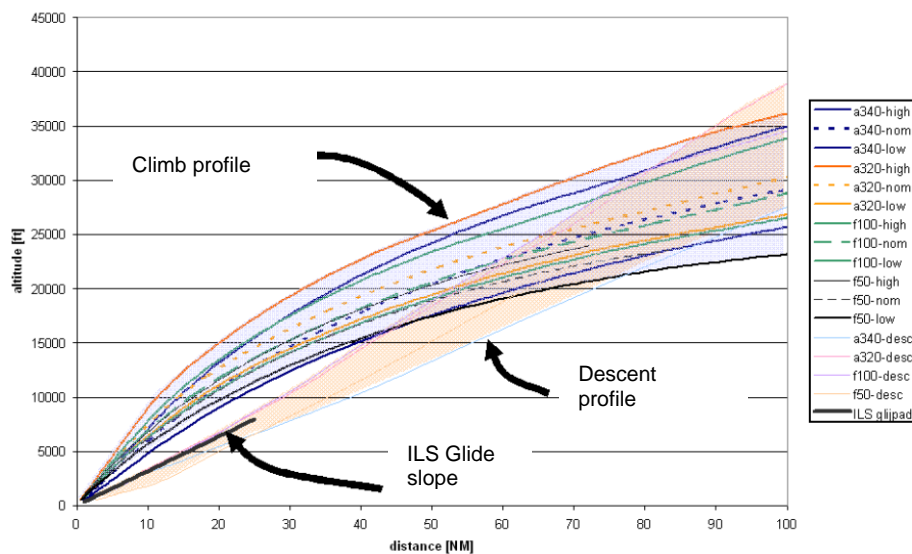
- a) **Low traffic scenario.** The separation of commercial aircraft is seldom required at a low traffic airport and STAR and approach procedures, which include optimized profiles, can be implemented easily. This can be achieved using either pre-defined procedures or radar vectoring.
- b) **Medium traffic scenario.** For the purposes of this manual, a medium traffic airport is an airport where the number of aircraft being sequenced to a runway at a given time is such that not all of them can be accommodated by CD on a fixed route. The aim is to sequence aircraft, where necessary, prior to a merge point after which a CD is performed. The merge point has to be determined first. In order to maintain a similar TAS between aircraft, regardless of their different altitudes, the sequencing area is defined vertically by the altitude of the merge point and 3000ft above the altitude of the merge point. This 3000 ft altitude range guarantees, for common meteorological parameters, that TAS differences between aircraft (for similar aircraft types) will not be greater than 5%. The Point Merge concept can often be applied in such scenarios.
- c) **Heavy traffic scenario.** For purposes of this manual, a heavy traffic airport is an airport where the average number of aircraft sequenced to a runway at a given time is such that the capacity demand cannot be accommodated when a full CD implementation is applied. In heavy traffic scenarios, the downwind leg is reached from a STAR followed by an initial approach which may include merge points. CD is flown to waypoint DTW (see *Figure 10*) where an altitude range may be applied to facilitate a variable vertical flight path. This altitude bracket should be low and narrow enough to allow the air traffic controller to provide coherent radar sequencing within the downwind area. The end of the downwind leg is defined by a specific point called Downwind Termination Waypoint (DTW) and is used as the CD anchoring point. From this point, the aircraft is either cleared to continue on the procedure, when it can continue flying CD, or it remains on the downwind leg awaiting radar vectors.



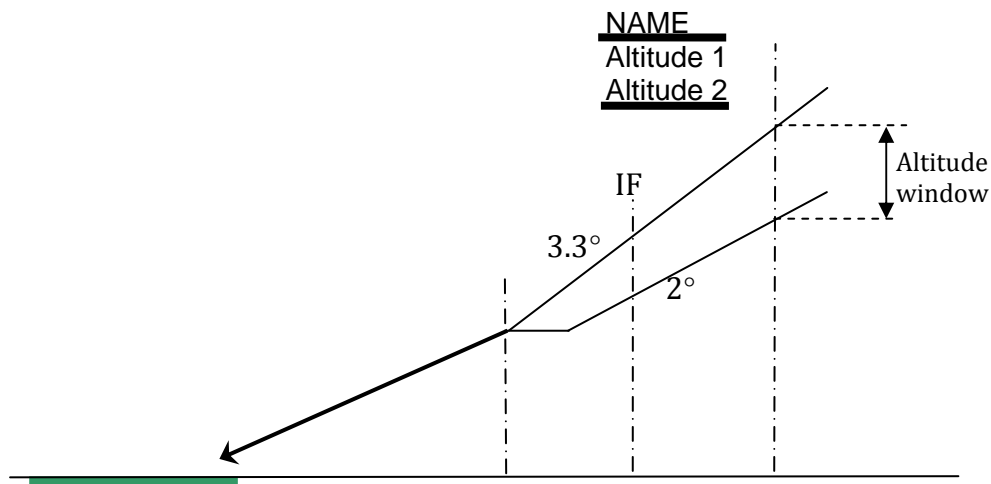
**Figure 10 - Heavy Traffic Scenarios (Hybrid Technique)**

## 3.1.4 Altitude Restrictions

The introduction of CD's through optimized profiles may have an effect on both en-route and terminal airspace design. The facilitation of CDs for a range of aircraft types in a range of meteorological conditions may require large altitude window constraints. This needs to be taken into account in the location, design and de-confliction of the arrival routes with respect to departure routes. When the arrival routes cross departure streams close to the airport, it may still be possible to keep the outgoing traffic below the arrivals. Further from the airport, it is often more efficient to allow the departures to climb above the arrivals. The location of the possible conflict points may change with different aircraft performances and routes may have to be realigned.



**Fig 11: Indication of vertical profiles arrival/departure streams**



**Fig. 12: Need for altitude windows**

Where fixed lateral paths are used, the need to establish CD minimum and/or maximum altitudes along the route may occur for the following reasons:

- a) to define a minimum altitude or an altitude window to avoid conflict between CD procedures and SIDs.
- b) to let ATC know within which range of altitudes an aircraft executing CD operations will operate.

The nominal vertical profile should be as close as possible to 3° (5.24%) and level flight segments should be avoided prior to the IF. The vertical path may vary between 3.3° and 2° in terminal airspace and between even greater/lesser values further from the airport.

See Appendix B for aircraft specific details (awaiting OEM response) TBD

*Note: Minimum altitudes prescribed in a CD environment should be equal to or higher than the obstacle clearance altitude prescribed at the same point.*

### **3.1.5 Speed Restrictions**

Any speed restriction should take the distance to the runway along the theoretical flight path into account. Speed constraints reduce the flexibility of the CD operation but can aid optimum traffic sequencing. In general, the 250kts IAS below FL100 should be applied although aircraft specific limitations should be taken into account.

With prior planning, speed control can be factored in by the flight crew and accomplished without use of drag or level flight.

### **3.1.6 Transition Level**

If a CD starts above the Transition Level, a buffer should be established by the procedure designer and added to the minimum altitudes along the path. This buffer will be calculated based upon the airport historical pressure altitude range.

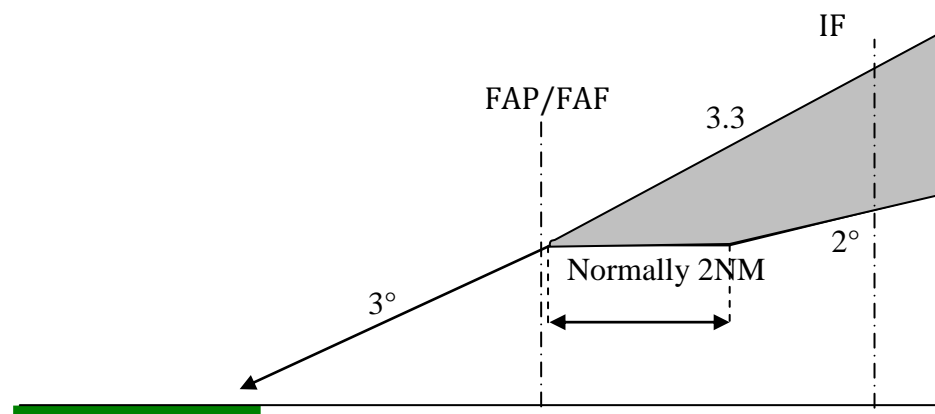
### 3.1.7 Database coding

After the DTW, an FM path terminator should be coded. If ATC require, a VM path terminator can be used instead. The following leg should be coded CF or DF to the Intermediate Fix.

### 3.1.8 Intermediate Approach Segment

There should not be any ambiguity regarding the intermediate approach segment. On an approach procedure flown with a CD, an intermediate segment should be provided in compliance with Doc 8168 criteria. Procedure designers should include a level segment of 2 to 5 NM in length, prior to the final approach intercept point. A minimum and a maximum altitude should be charted at the IF for this segment. The minimum altitude should be calculated with a slope  $\leq 2^\circ$ , the maximum altitude will be calculated with a GP slope ( $3.3^\circ$ ). In the case of an ILS GP slope greater than  $3.3^\circ$  it will be necessary to implement a more detailed study to ensure all appropriate types of aircraft are accommodated.

Deceleration and configuration changes may take place as a continuous and gradual process while descending at a reduced descent rate and a pilot flying a CD would not normally use this level segment.



**Figure 13 - Intercepting the FAP**

### **3.2 CHARTING ISSUES**

3 types of charts may be involved in CD operations:

- a) STAR
- b) Approach chart used for a procedure designed for a CD operations
- c) Approach chart used for a procedure which can be flown by CD or non CD.

A CD in the STAR phase of flight generally does little to improve noise abatement but can provide significant fuel and emissions benefits.

There is no need to provide specific altitude windows or speed restrictions for CD operations on STAR charts unless they are required to meet airspace restrictions or ATC requirements.

If an approach procedure has the option of being flown with or without a CD, these two options may have to be charted separately.

At or beyond the IAF, speed and altitude restrictions should be clearly depicted on the chart.

Altitude restrictions should be expressed using altitude windows (with minimum and maximum altitudes), or by “at or above” or “at or below” constraints.

If the CD operation is only applicable to a part of a path, this should be unambiguous to both pilots and ATC. If it is necessary, the beginning and the end of a path where a CD technique may be applied should be indicated on the chart.



## **3.3 FLIGHT OPERATION.**

*Refer to PANS-OPS Volume I.*

### **3.3.1 General**

The optimum CD is flown as a continuous descending flight path with a minimum of level segments and engine thrust/engine thrust changes, and as far as possible in a low drag configuration. Before interception of the final approach segment, aircraft speed and configuration changes have to take place: the extension of slats, flaps and landing gear. This configuration process should be managed with care in order to minimise risk of unnecessary thrust setting, but it should conform to the standard procedures for configuring the aircraft for landing as detailed in the aircraft operating manual. If available and whenever possible the vertical path as calculated by the FMC should be used.

Specifically, techniques that enable a fuel efficient (minimum thrust), optimum descent and approach should be used wherever and whenever possible. The total energy of the aircraft at high altitude can be used most efficiently during descent with minimum thrust and drag. However, the pilot should have the maximum flexibility to manage the aircraft's speed and rate of descent. For aircraft equipped with Flight Management Systems with Vertical Navigation (VNAV) capability, an optimum descent can be planned and executed with a fixed lateral flight path stored in the navigation database.

The instrument flight procedure may have been designed to facilitate CD all the way to the FAF/FAP, from a merge point to the FAF/FAP or via one or more merge points to the downwind leg for radar vectors to the FAF/FAP. This should be clearly indicated on the chart. The availability of the full CD procedure may depend upon the traffic levels and the controller workload.

The pilot in command should attempt to conduct a continuous descent within operational limits when feasible. The final authority over the operation of the aircraft will always remain with the pilot in command and stabilisation of the aircraft state during the final approach should never be compromised.

### **3.3.2 Transition Level**

If a CD starts above the Transition Level, and there is a significant difference between the local and the standard pressure, the vertical flight path will be affected and a temporary change of the vertical descent rate may be observed.

### **3.3.3 Cockpit Workload**

Cockpit workload may be an issue in the execution of a CD operation.

Variations in the weather conditions, such as (changing) wind speed and direction, atmospheric pressure, temperature or icing conditions which require the use of anti-ice systems, etc, or in the lateral flight path, due to ATC instructions, may require active pilot intervention to remain close to the optimum vertical flight path. Airspace and ATC flexibility in the CD segment should accommodate these operational variances and keep the cockpit workload manageable and the success rate high.

A procedure designed for CD should keep the workload required for a continuous descent within the limits expected for normal flight operations. The lateral and vertical flight path generated by the onboard computer should be easily modified by the flight crew using normal data entry procedures to accommodate tactical adjustments by ATC and variations in wind speed and direction, atmospheric pressure, temperature or icing conditions etc. In certain flight regimes, such as radar vectors, such modification may not be possible, causing a significant decrease in the ability of the aircraft to accurately fly an optimized profile.

ATC should provide the cockpit crew with timely information, tactical spacing and operational flexibility in order to facilitate a CD. Additional speed or altitude constraints may increase pilot workload and reduce procedure effectiveness.

It is assumed that ATC is aware that a continuous descent will be applied when cleared for the route to be flown. This should be inherent in the route and descent clearance given and should be depicted on the chart. The design profile should support a CD and the airspace below and above the depicted flight path should be kept free from other traffic. If necessary, due to traffic or other circumstances, ATC may issue an amended clearance with new altitude or speed restrictions, thereby terminating the CD.

A descent clearance will not be given earlier than necessary but should ideally be given as close as possible to a distance from touchdown from where an optimised CD will naturally result (and hence the least track miles). The phraseology "Descend at pilots discretion" allows such flexibility to the operation.

### **3.3.4 Pilot Training**

General training is not required. However, optimum execution of a CD may require additional actions to be taken by the pilot flying. The basic route and crossing restrictions for the CD procedure should be published as part of the arrival procedure. Effective and precise execution of a CD may require procedure specific issues to be briefed prior to starting the arrival such as:

- a) any speed restrictions,
- b) any altitude constraints or crossing restrictions,
- c) the level of automation to be used,
- d) the possible effect of wind, atmospheric pressure and altimeter setting, expected icing conditions,
- e) the effect of the transition level if applicable,
- f) any ATC instructions given, etc.

### 3.4 ATC TECHNIQUES

*Refer to PANS-ATM (Doc 4444) for more details.*

#### 3.4.1 General

Maximum effective execution of a CD requires flexible airspace design and sectorisation with sufficient room to allow the aircraft to descend in accordance with the parameters computed by the Flight Management Computer (FMC). The vertical path may vary between 3.3° and 2° in terminal airspace and between even greater/lesser values further from the airport. The imposition of any additional constraints on aircraft performance in the form of an assigned speed, heading or altitude, will create additional workload for the flight crew and could hinder or prevent the aircraft from achieving an optimum CD. A flight path extension will place the aircraft below the optimum path and a shortening of the route will place the aircraft above the optimum path. In the first case, more thrust may be required to achieve the desired arrival or approach descent profile; in the second, additional drag which can create an increase in noise on the ground may be required to recapture the optimized profile or approach path. As far as practicable, the controller should refrain from modifying the flight path.

The pilot in command will attempt to conduct a continuous descent within operational limits when feasible. The final authority over the operation of the aircraft will always remain with the pilot in command and stabilisation of the aircraft state during the final approach will never be compromised.

As discussed in chapter 4, there are three different options for constructing and/or executing a CD procedure:

- g) A continuous descent embedded in a published STAR, Initial Approach or other form of pre-defined flight path;
- h) A continuous descent facilitated by ATC using radar vectors and providing distance to the runway threshold;
- i) A hybrid of the two designs above. The hybrid option can have an open or closed downwind leg.

Ground tracks of CD's based on radar vectors will be less consistent than those based on computer-generated profiles calculated on a fixed pre-defined lateral route. This type of CD, which can also be flown by aircraft without an RNAV capability or Flight Management System, requires specific operational knowledge, controller skill and experience. The controller should estimate the approximate track miles to be reported to the crew for optimum descent planning based on several variables, including the expected route to be flown, wind effects, aircraft performance, pilot reaction time etc. In the case of a CD based on radar vectors, the pilot may need to concentrate more on the optimisation of the descent profile, compared to a CD based on a pre-defined route. This may conflict with other pilot responsibilities associated with approach and landing. An assessment of the positive and negative workload effects for the entire descent should be undertaken and taken into account.

A CD based on radar vectors can also be seen as an initial step towards the implementation of more sophisticated CD operation, based partly or completely on fixed lateral flight paths, while maintaining the required Airport Arrival Rate.

### **3.4.2 Transition Level**

If a CD starts above the Transition Level, a buffer will be taken into account by the procedure designer and added to the minimum altitudes along the path. This buffer has been calculated based upon the airport historical **QNH** range.

### **3.4.3 CD, Optimal AAR and ATFM considerations**

Variations in aircraft performance, including descent rates, optimum descent points and speeds, may make it difficult in the near term to utilize CD procedures fully on a published fixed route while maintaining the maximum runway capacity. Traffic demand may dictate tactical adjustments to arrival flows to ensure the maximum throughput. Where a fixed lateral route is used, the runway capacity is a direct function of the length of the procedure: the longer the fixed flight path, the more difficult it is to maintain the capacity. Pre-sequencing of the traffic prior to the merge point is essential to achieve the maximum capacity. The more effectively aircraft are sequenced and merged, the greater the likelihood that aircraft can maintain the optimum CD. Pre-sequencing traffic may take the form of predetermined circular holding, tactical lateral path stretching (using radar vectors or point merge techniques) and/or speed intervention all of which have adverse environmental consequences. New automation tools may become available in the future, to support this sequencing and merging process, further optimising the CD operation.

A hybrid design can be based on a published fixed route until a point on the downwind leg (refer to Fig 14: Downwind Termination Waypoint, DTW). This design gives ATC flexibility to meter and sequence traffic for final approach by extending the downwind leg(s). This may be sub-optimal for the CD, as the change of the lateral flight path results in a change in the vertical profile and therefore the engine thrust setting and/or drag. The extension of the downwind leg also results in a spreading of flight paths, vertically and laterally, which may affect noise levels (contours) in the vicinity of the airport.

During peak periods, depending on the runway configuration, simultaneous CD may not be compatible with parallel runway operations, where there is a requirement for 1000 feet of vertical separation in the intermediate segment of the approach.

The lack of a horizontal segment in case of a CD may require dependent operations with longitudinal separation prior to intercepting the final approach. This brings an associated decrease in capacity or the utilisation of extreme shallow final approach intercept angles which are operationally challenging for the flight crew but which will allow ATC more time for surveillance and communication.

### **3.4.4 ATC Training**

Air traffic control should gain a thorough understanding of the operational benefits and consequences with regard to manipulation of CD profiles, the procedures associated with CDs and in particular the type of CD facilitation being deployed at the airport they serve. Where radar vectors are used to facilitate a CD, dedicated training may be required. The use of a radar-vectorised CD requires specific knowledge and skills. Where flight path and profile behaviour for different types of aircraft are required knowledge, actual experience should be gained. On the job training, or realistic simulation exercises, will be an essential part of the training process to ensure controller proficiency in order to verify the controllers' performance.

During the CD design phase or prior to flight trials, joint ATC and flight simulation will allow controllers and pilots to better understand the issues and limitations that they each face.

### **3.4.5 ATC workload**

Specifically, where radar vectors are used to facilitate CDs, ATC workload may be higher. The Distance to Go information provided to the pilot requires the controller to predict the actual flight path miles to be flown. Ideally, the sequencing of the aircraft should be established prior to the initiation of the CD. Holding, lateral path stretching or speed intervention may be used for this purpose. It should be noted that the application of any of these techniques will result in increased fuel consumption and emissions. Further, as distance to go information cannot be automatically integrated into the predicted vertical path, the results achieved will be at best rough estimates of what an optimal path might be. ATC should provide the cockpit crew with timely information, tactical spacing and operational flexibility in order to facilitate a CD. Additional speed or altitude constraints may increase pilot workload and reduce procedure effectiveness.

It is assumed that ATC is aware that a CD will be applied when cleared for the route to be flown. This should be inherent in the route and descent clearance given and will be depicted on the chart. The designed vertical profile supports a CD and the airspace below and above the depicted flight path should be kept free from other traffic. If necessary, due to traffic or other circumstances, ATC may issue an amended clearance with new altitude or speed restrictions, thereby terminating the continuous descent. A descent clearance should not be given earlier than necessary and should ideally be given as close as possible to a distance from touchdown from where an optimised CD will naturally result (and hence the least track miles). The phraseology "Descend at pilots discretion" allows such flexibility to the operation.

### **3.4.6 ATC Facilitations**

#### **3.4.6.1 Different CD options**

The initiation point of a CD is a decisive factor to define the way the CD will be performed and to identify the relevant actions.

Ideally (beneficial for fuel and emission) a CD should start at the end of the en-route flight and be initiated as close as possible at the Top of Descent (TOD). An initial descent with minimum thrust setting can be seen as normal practice where and whenever possible. During that phase of flight there may be large vertical margins and sequencing does may not yet play an essential role.

Well before TOD, data must be loaded into the FMC to enable a CD (winds/temperature, route adjustments, speed and altitude restrictions/requirements). In addition, some pilots' preference for use of an early descent functions to minimize passenger discomfort on descent initiation need to be taken into account. Changes in vertical flight paths can have a significant effect on letters of agreement between airspace sectors and FIR's and must therefore be taken into account.

CDs may start anywhere from the TOD, on the STAR, at, or beyond, the IAF. At lower altitude, in the range where climbing and descending traffic meet and closer to the point where ATC needs to merge and sequence the traffic CD becomes a limiting factor for capacity.

### 3.4.6.2 Sequencing Techniques in Relation to CD and Optimal AAR

The application of CD in the air traffic system, including aircraft sequencing and runway capacity, depends on density and type of traffic involved. This could depend on time of the day or the size of the airport. From strictly an environmental standpoint, a CD can be beneficial regardless of airport size. However, from a runway capacity or system efficiency standpoint, CD can potentially have an overall negative impact on medium or, in particular, heavy traffic. Except for very complex airspaces it should be possible to facilitate some degree of CD at most airports.

While the use of a CD will always be seen as an environmental benefit, whatever the size of the airport, the operational consequences should be considered for any application.

To implement a CD to an airport, it is necessary to identify the following airport traffic scenarios:

- a) **Low traffic scenario.** The separation of commercial aircraft is seldom required at an airport with low traffic. STAR and approach procedures, which include optimized profiles, can be implemented easily.
- b) **Medium traffic scenario.** For the purposes of this manual, a medium traffic airport is an airport where the number of aircraft being sequenced to a runway at a given time is such that not all of them can be accommodated by CD on a fixed route.
- c) **Heavy traffic scenario.** For purposes of this manual, a heavy traffic airport is an airport where the average number of aircraft sequenced to a runway at a given time is such that the capacity demand cannot be accommodated when a full CD implementation is applied.

The indicated scenarios above do not preclude the ad-hoc application of CD operations at certain hours of the day or night, where even a heavy traffic airport would fall in a low traffic scenario option.

ATC has a requirement to direct aircraft to provide spacing and to maintain an optimal AAR. In a low traffic scenario, this can be achieved with CD using pre-defined fixed routes. In medium traffic and heavy traffic scenarios, two different techniques, based upon the hybrid concept, can be used.

ATC should be able to choose the best mix of facilitation techniques as indicated above, to suit the present and future traffic scenarios. Where feasible, CD using pre-planned profiles should be facilitated from as high as possible, using the full capability of onboard systems (including STARS, RNAV1 or RNP1 and sequencing

tools etc). Where this is not yet possible, reversion to tactical 'radar' facilitated CD may be necessary when traffic or operational requirements dictate.

ATC should:

- avoid trying to implement CD on fixed lateral routes in traffic levels where it is possible that the CD will be interrupted by ATC in order to sequence;
- make use of tactical opportunities to offer CD from top of descent;
- seek to optimise the number of and extent of CD over time;
- offer 'descend at pilot's discretion' CD clearances, to allow the pilot to optimise their decent profiles within ATC requirements.

### **3.4.6.3 Hybrid Technique to be Applied in Medium Traffic Scenarios**

In medium traffic scenarios, there is no need to sequence all the incoming aircraft. During a traffic hour there will be a number of "traffic gaps" lasting some minutes. These traffic gaps are used to make a break between successive waves of aircraft to be sequenced.

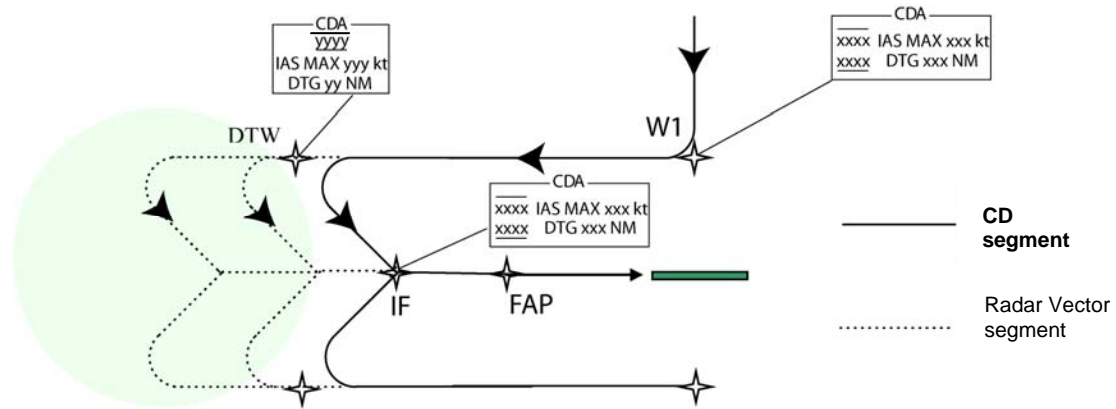
The aim of a hybrid CD implementation at medium traffic airports is for air traffic to sequence aircraft to the point where CD may then be flown, to the runway. This is usually to achieve a noise abatement objective. ATC sequences the aircraft prior to the CD start point, while aircraft may be descending or in level flight.

This sequencing will be achieved using radar vectoring by ATC or by using a sequencing tool to define the optimum lateral path (generally defined by waypoints) prior to the merge point.

In order to maintain a coherent TAS between aircraft, regardless of their different altitudes, the sequencing area is defined vertically by the altitude of the merge point and 3000ft above the altitude of the merge point. This 3000 ft altitude range guarantees, for common meteorological parameters, that TAS differences between aircraft (for similar aircraft types) will not be greater than 5%.

### **3.4.6.4 Hybrid Technique to be Applied in Heavy Traffic Scenarios**

From a STAR followed by an initial approach, which may have included merge points, the downwind leg is reached using CD to waypoint Downwind Termination Waypoint (DTW) as indicated in Figure .



**Figure 14 - Hybrid Technique in Heavy Traffic Scenarios**

The end of the downwind leg is defined by the DTW.

From this point:

- a) outside a sequencing period, the aircraft follows the instrument approach procedure, flying a CD to the Glide Path intercept Point (FAP);
- b) if the aircraft is arriving during a sequencing period, it continues on the downwind leg until ATC provides radar vectoring to intercept the final approach track. In this case the CD may be interrupted and a level flight will occur. However a CD may be continued if ATC provides Distances To Go information to the threshold and keeps the aircraft descending.



## **CD IMPLEMENTATION**

### **1 OVERVIEW AND PRE-REQUISITES**

#### **1.1 INTRODUCTION**

This section offers a model process for implementing CD. This implementation guidance is not meant to be a blueprint and may need to be modified to account for local differences. In implementing CD it may be that multiple iterations of the current step or previous steps are required in the light of operational experience or new information. The process for implementing CD can be applied to other aircraft operational environmental initiatives at an airport; the collaborative arrangements being particularly useful.

#### **1.2 CD IMPLEMENTATION PRINCIPLES**

Before and during the implementation process, it is important to follow the following principles:

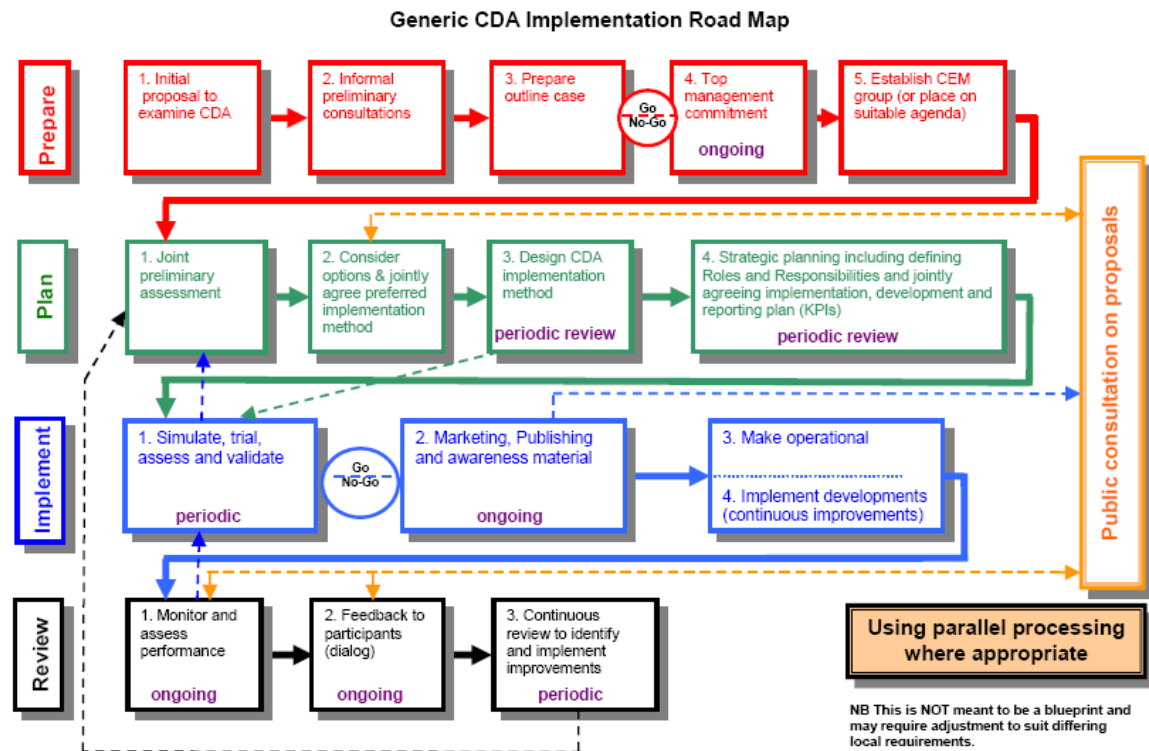
- a) Safety remains paramount.
- b) CD down to FAP/FAF may not always be appropriate. However, a hybrid approach of a CD to a specified altitude and waypoint, followed by vectors to the FAF may be a solution.
- c) CD should not be considered in isolation but rather in the light of the total current operations (e.g. the implications for departures) and any planned changes, (e.g. plans to implement airspace changes, RNAV1 or controller tools).
- d) The effectiveness of a CD relies on keeping the aircraft as high as possible for as long as possible, avoiding early or late descent clearances, using minimum thrust whenever possible and avoiding unnecessary level flight while allowing the aircraft to fly at speeds that permit them to operate as efficiently as possible.
- e) Collaboration between ANSP, Aircraft Operator and Airport Operator is essential.
- f) An Optimum CD requires a fixed lateral path but do not have to follow fixed vertical paths: they can be facilitated by descents at a pilot's discretion with controller support.
- g) At higher altitude, noise is less important (to be decided locally), fuel and Carbon Dioxide reductions become the main aims.
- h) Energy management is critical to a successful CD - speed control can help— a small reduction in approach speed can reduce the noise impact significantly
- i) A full CD from Top of Descent is ideal and may be tactically possible during low traffic periods

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- j) CDs within individual sectors and at lower altitudes are still very worthwhile (+/- 50 to 100kg fuel saved per flight).
- k) Different CD profiles can be used at one airport to suit changing scenarios. However, adequate controller training and procedures should be implemented to avoid potential confusion if differing CD profiles are to be used.
- l) CD is the art of the possible and should not impact capacity, start simple and build on experience. This prepares for new technologies.
- m) A CD should not cause a greater disbenefit for other operations.
- n) Assessing the performance baseline is therefore an essential first step.
- o) Changes to aircraft flight tracks over the ground may require consultation with external communities – this may be a legal requirement.

### 1.3 IMPLEMENTATION PROCESS DIAGRAM

The following diagram shows the process for effectively implementing CD.



## **1.4 THE IMPORTANCE OF EFFECTIVE COLLABORATION**

No single stakeholder can successfully implement CD unilaterally. It is recommended that CD is placed on the agenda of an existing collaborative group or triggers the formation of a CD specific CD collaborative group (recommended). Full CD performance will not be achieved over night, indeed CD should be seen as a journey not a destination.

Refer to the appendix to this attachment for a specimen TOR for a CD Implementation Collaborative Group (CG) and a CD Implementation Group (CIG).

## **1.5 COMMUNITY RELATIONS AND CONSULTATION**

Introducing CDs may offer noise benefits but may also change the nature or locations of noise impacts<sup>3</sup>. Whilst the majority may benefit from reduced noise there may be a minority for whom the noise increases. External consultation with interested parties may therefore be required at the option selection stage and land-use planning zones may need to be altered. This consultation should be handled through established community relations channels where they exist.

It is important to communicate successful implementation and positive performance

## **1.6 POLICY CONTEXT**

Understanding the policy context is important for making the case for local CD implementation and ensuring high levels of participation. CD may be a strategic objective at International, State, or local level, and as such, may trigger a review of airspace structure Noise contour production may already assume CDFA (i.e. a (3<sup>rd</sup>) Continuous Descent Final Approach) and thus even if noise performance is improved in some areas around the airport, it may not affect existing noise contours. Similarly, CD operations may not affect flight performance within the area of the most significant noise contours (i.e., those depicting noise levels upon which decision making is based). It is important not to raise unrealistic public expectations.

In addition to a safety assessment, a transparent (published) impact assessment of CD covering effects on other air traffic operations and associated environmental impacts.

Simple ways to facilitate CD, especially in low traffic periods, can be implemented quite rapidly. The ultimate aim should be to facilitate the optimum CD from Top of Descent to final approach in all traffic densities. However, today, even in periods of moderate traffic, this is not always possible with existing technology. In the future, more sophisticated traffic flow management automation tools should allow continuous descents to be flown in all traffic and weather conditions.

Thus, the initial simple or limited implementation of CD should be seen as the first steps towards continual CD improvement. A no-blame culture will be essential to allow open and frank discussion on performance issues in order to underpin continual improvement.

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<sup>3</sup> For example introducing CD compliant STARS may result in concentrating flight over route centrelines, facilitating CD using Point Merge techniques may change where aircraft fly, and so on.

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For some airports, because of complexity, adverse trade-offs or airspace restrictions, CD may not be possible. It is important to compile a report detailing the process used to arrive at the final conclusions and the reasoning for rejecting the introduction of CDs, to facilitate dialogue with the community or rule makers. This will also help to inform future consideration of CD.

### **1.7 IMPLEMENTATION STEPS**

The following steps provide a map to successful CD implementation. The degree of effort or time spent on each step will depend on a number of local factors including the degree to which operational collaboration is already part of the airport culture. The process is based on the classic plan-do-check-act philosophy and is comprised of four main CD implementation phases.

## 2 PREPARE



### 2.1 INITIAL PROPOSAL TO CONSIDER CD OPERATIONS.

The initiation of CD may be proposed by any operational stakeholder and should follow this guidance.

The individual proposing CD operations is hereinafter referred to as the 'Initiator'

It may not be possible for the initiator to undertake a full preliminary CD viability assessment at this stage; however the policy context may provide justification:

- National or local regulatory guidance;.
- airport and/or airspace development plans;
- existing plans for CD (if any);
- sources of guidance and practical support;.
- generic potential benefits and risks; and,
- (optional) an outline proposal for preliminary informal consultation processes.

In the light of this informal review against the above, the initiator should prepare a short preliminary report to test interest from fellow operational stakeholders. It is important to engage all key operational stakeholders at an early stage using informal networks. This can be achieved very effectively through an airport, multi-airport or national CD workshop designed to:

- reach a common understanding of the present operational situation at the airport(s) – and potential operational improvements;
- reach a common understanding on CD related opportunities, benefits, gaps, issues and risks from different operational perspectives;
- jointly decide if CD is considered viable enough to continue with the implementation process (next steps) – (go-no-go);
- agree on an 'in principle' way forward (next few steps) to implement this guidance;
- nominate (initial) points of contact, actions arising from workshop and timelines.

The typical participants to such a workshop could include, inter alia:

Lead Carrier plus other interested airlines

- i) Senior Pilot(s)
- ii) Technical support (FMS expertise)
- iii) Policy/decision maker

ANSP

- i) Approach/Centre controllers
- ii) Airspace designers
- iii) Procedure designers

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## Airport Operator

- i) Environment Department
- ii) Operations

## Optional

- i) Aviation regulator
- ii) Ministry of Transport
- iii) Industry representatives
- iv) International Agencies (where appropriate)

## 2.2 PREPARE AN OUTLINE CD CASE

A well constructed case for CD will secure the essential top management commitment and hence resources to take CD forward. The outline case can be largely constructed from the workshop outcome in the previous implementation step. A model layout is as follows:

- outline description of the proposed CD operation, its stimulus and the policy context;
- description of practical support available;
- outline estimation of potential benefits and costs (outline benefits are covered later in this document);
- outline implementation road map including approvals required and go-no-go decision points and proposed working arrangements (points of contact) and proposed lead stakeholder<sup>4</sup> (including project leader if known);
- top commitment requirements (what is expected from CD sponsors);
- recommendations;
- annexes:
  - i) Description and outcomes from the workshop
  - ii) Potential CD facilitation candidates
  - iii) Gaps and risks

For CD to be successful, senior management commitment is essential for each stakeholder in order to give the work priority, drive progress and release the required resources. For some States, and especially where operational stakeholders are State authorities, a formal or legal agreement may be required to allow collaboration to take place. In some cases, approval from a State authority (e.g. the Aviation Regulator) may be required to allow the CD implementation to progress past a certain point.

## 2.3 ESTABLISH COLLABORATIVE CD IMPLEMENTATION GROUP

Once top management commitment is confirmed, the informal consultation arrangements and agreed points of contact should be consolidated into a formal working arrangement.

Early tasks will include:

- ensuring a common understanding of the work undertaken so far;
- agreeing on Terms of Reference (model TOR's available in Appendix A);
- identifying skill requirements and co-opting members or informing supporters of potential support requirements accordingly;
- agreeing on the initial road-map – the road map in this guidance may be used – but with more detail on the planning phase;

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<sup>4</sup> If CD is driven by noise abatement requirements, the lead stakeholder could be the organisation with legal environmental accountability which is often the aerodrome operator.

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- agreeing on roles and responsibilities;
- establishing consultation and reporting processes.



## 3 PLAN



### 3.1 JOINT PRELIMINARY ASSESSMENT

A robust joint preliminary assessment of CD will ensure that subsequent CD implementation steps are based on robust foundations. The overall aim is to jointly determine whether CD is likely to be viable.

This will require joint consideration of:

- what is the base-case<sup>5</sup>
- what performance changes (+/-) could arise from CD
- what direct and indirect barriers, risks and enablers exist (at a high level)
- what CD facilitation alternatives and combinations should be considered.

The scopes for the preliminary assessment should be wide-ranging, but outline in depth and could consider fundamental questions such as:

- where do aircraft fly in relations to population centres and complaints?
- How do arrivals and departures interact?
- What do present vertical arrival/approach and departure (track monitoring system, radar/flight recorder information) profiles look like now – how much level flight is there on arrival/approach?
- How much CD occurs at present?
- What relevant plans or developments are underway at the airport?
- What future-case CD facilitations options could we build towards?
- What are the relevant regulations and policies (e.g. consultation)?
- What capabilities do we need (e.g. ATC/flight simulation monitoring, feedback loops etc)?
- What related effects may exist (e.g. effects on capacity or departure profiles etc)?
- What risks exist and what mitigation is required? e.g.: how may growth affect our ability to perform CD? – don't promise perfect performance; and how might consultation obligations delay CD implementation?
- What change to noise impact may occur (e.g. change to geographical locations of noise impact, concentration or dispersion of noise impact)?
- What quick-win opportunities exist (e.g. rapid implementation of tactical CD in very low traffic scenarios)?

### 3.2 CONSIDER OPTIONS AND JOINTLY AGREE ON PREFERRED IMPLEMENTATION OPTIONS

It is essential to consider all of the options for CD facilitation and the scope (e.g. distance and starting altitudes). This is especially important if the assessment method is governed by environmental impact assessment legislation that mandates that alternatives are considered.

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<sup>5</sup> The base case may be the present pre-CD case, but if CD is part of a wider operational change or infrastructure development, the Base-case may be the future 'do nothing' or 'no-CD' case, in accordance with planning horizon timeframes.

These alternatives could include:

- CD facilitation methods described previously in this document;
- phased introduction during low traffic periods;
- phased introduction during heavier traffic with automation support or other facilitation;
- single or combined facilitation methods (e.g. RNAV CD compliant routes in busy periods and tactical radar based methods in less-busy periods);
- combining RNAV routes in the earlier stages of arrival/approach where sequencing is less difficult with tactical radar based techniques at lower altitudes where the landing sequence is being directed;
- combining procedural and radar-tactical techniques such as 'Point Merge' where an RNAV fixed route approach is provided with the intention of offering a 'Direct To' instruction to vector aircraft from the route, towards a fixed 'merge point';
- initiating CD from different altitudes during different traffic densities;
- facilitating CD from Top of Descent in less busy periods.

### **3.3 DESIGN PREFERRED CD FACILITATIONS OPTION(S)**

At this stage, a final CD implementation solution will have been described together with adequate reasoning to explain how and why this was selected.

This preferred option now needs to be designed and this will require the following:

- review of applicable rules or guidance and compliance assurance;
- Airspace changes if needed;
- facilitation procedure design (e.g. RNAV1 routes, Point-Merge);
- required changes to operator and ANSP SOP's;
- pre-requisite technical enablers that are assumed to be delivered in time for implementation to commence (e.g. A-MAN, NAVAID's, software etc);
- training requirements;
- a more detailed safety assessment.

### **3.4 STRATEGIC PLANNING**

It is important that everyone agrees and buys into the Strategic Plan for implementing the preferred CD option.

This will include joint agreement on:

- basic project management;
- phasing of CD continuing development (what small steps towards what long term vision?);
- critical path activities and their management;
- roles and responsibilities;
- reporting structures both for project management and CD implementation assessment purposes;
- CD implementation KPIs (e.g. % CD achievement and/or tonnes of fuel & emissions saved);
- the operational trial safety requirements to ensure that simulation and validation testing result in a safe operational trial;
- risk management.

## 4 IMPLEMENT



### 4.1 SIMULATE AND VALIDATE

At this stage more detailed flight and ATC simulation is recommended to include participation of those people who will be involved in implementing any trial. This helps to double-check the viability of the preferred option and to foster buy-in and understanding before live trials commence.

Prior to flight trials, joint ATC and flight simulation will allow controllers and pilots to better understand the issues and limitations that they each face.

The initial safety assessment should be rechecked and updated if necessary with the aim of allowing an operational flight trial. This may require endorsement by the Aviation Regulator. Assuming that the preferred option is validated, the strategic plan should be jointly upgraded to an implementation plan, including specific accountabilities, general communications processes, training, dealing with unplanned events or variance from plan and rapid reporting of safety issues using established processes. The trial plan and its implementation should be jointly agreed as fail-safe prior to initiation of CD operations.

### 4.2 DECISION POINT (GO-NO-GO)

Based on the outcome of the simulation and validation activities at this point, the plans to proceed should be endorsed by senior management.

### 4.3 MAKE CD OPERATIONAL AND IMPLEMENT ITERATIVE IMPROVEMENTS

The Collaborative Group should meet to ensure that everyone involved understands the overall intentions and operation of the trial and their role in it.

The trial should be implemented initially on a very limited basis, if appropriate, for a single runway, in light traffic and with only the lead carrier or a limited number of aircraft operators.

Performance monitoring will be important and there will be a need to correlate:

- whether and how a CD was offered or followed;
- flight identification;
- flight performance information;
- reasons for non-compliance (if any).

All parties involved in the CD trial should be informed of the intention to proceed and given access to the trial plan. This will include delegated accountability for making operational staff ready to proceed to the operational trial. Training should be undertaken and the trial published through established formal processes (e.g. AIC, NOTAMS, AIP, airport bulletin, or ATC advisory).

### **4.3.1 Assessment**

Assessment of performance should be based on the progress results of the trial and should cover the Key Performance Areas of most relevance for local circumstances.

These may include:

- safety (mandatory – the safety case should be updated in the light of the trial);
- cost effectiveness and especially aircraft fuel savings;
- workload;
- environment impacts (noise, air quality and climate change impacts);
- capacity;
- training requirements;
- feedback to participants.

It will be essential to define the parameters by which to assess CD participation and performance. These should have sufficient flexibility to achieve a good balance between CD achievement in terms of numbers of compliant flights and individual CD performance.

### **4.3.2 Training, Marketing and Awareness Material**

To support full CD implementation local guidance and awareness should be produced and promulgated alongside to the formal publication of the CD requirements through approved (State) channels.

This supporting material could include:

- CD Benefits and their local importance;
- training requirements for the selected CD facilitation method;
- a simple pamphlet describing the aims and requirements for CD;
- the roles and responsibilities required for the implementation of a single CD flight;
- ongoing feedback to participants on progress.

Building on the previous two-way consultation process, the local community should also be informed of the intention to proceed from trial to full implementation. Processes for ongoing community engagement and information should be developed.

## **4.4 FULL OPERATION**

Based on the trials full implementation of CD should be progressed through established channels.

The following issues should be considered:

- statutory consultation obligations;
- the nature of start up period (e.g. small steps – CD at night, limited to one runway etc);
- performance monitoring and review.

## 5 REVIEW



### 5.1 FEEDBACK TO PARTICIPANTS AND CONSULTATION

Regular feedback of CD performance to all operational stakeholders involved in implementing CD is critical to successful CD implementation, as is offering those involved the opportunity to suggest improvements. It is also essential to address specific improvements identified by the more formal review of specific issues that arise as part of performance monitoring.

It is also important to inform the community of ongoing progress and to seek their opinion and perceptions on the effects of CD through established channels. (see previous guidance).

### 5.2 CONTINUOUSLY REVIEW AND PLAN CD IMPROVEMENTS

The CD collaborative working arrangement (e.g. the CD Implementation Group) should also assume an ongoing responsibility to:

- review CD implementation progress and performance;
- monitor external developments in technology and practice;
- review potential local changes (e.g. airspace changes or implementation of new controller tools) that may present opportunities or risks for CD performance plan and implement improvements.

# Manual for Continuous Descent Operations

**CD IMPLEMENTATION COLLABORATIVE GROUP (CG) SPECIMEN TOR**

The Collaborative Group (CG) should ensure that all parties involved in implementing CD should maintain an up-to-date understanding of:

- p) which organisations are participating;
- q) their own role and responsibilities;
- r) the roles and responsibilities of other participants; and,
- s) the status of the CD (e.g. its definition and scope and when and how it is to be applied).

A simple CD Implementation Plan should be prepared and designed to fulfil the CG Terms of Reference.

CD facilitation should be designed in accordance with the criteria detailed in ICAO Doc 8168, Volume II, PANS-OPS.

Once draft procedures have been produced, an 'Interim CD Assessment' should be undertaken covering safety, capacity and workload issues.

Following a successful 'Interim CD Assessment' and adequate training of approach controllers and participating pilots, the provisional procedures should be implemented as a limited trial.

Following a successful trial, CD should be introduced commencing in periods of low density traffic and further deployment of CD should be decided by the appropriate authority.

Adequate local guidance, training and promotional activities and materials should be developed and applied to maximise the achievement of CD. This should be combined with regular feedback and reporting on CD compliance.

Once the CD procedure has been introduced, a continuous review of progress should be established in order to identify opportunities to improve performance, including suggestions from operational staff. Open reporting should be encouraged amongst all key members.

**CD IMPLEMENTATION GROUP (CIG) SPECIMEN TERMS OF REFERENCE**

The CD Implementation Group (CIG) should comprise senior representatives from the aerodrome operator, ANSP, lead carrier(s) and appropriate State authorities. If an existing body already exists where the required stakeholders are present, then the duties set out below can be formally included in the existing Terms of Reference for that body.

The CIG should ensure that all parties involved in implementing CD should maintain an up-to-date understanding of:

- t) what organisations are participating;
- u) their own role and responsibilities;
- v) the roles and responsibilities of other participants; and,
- w) the status of the CD procedure (e.g. its definition and scope and when and how it is to be applied).

A simple CD Implementation Plan is prepared.

Once draft procedures have been produced an 'Interim Assessment' should be undertaken covering safety, capacity and workload issues. A separate Hazard Analysis should be done prior to the start of the trial.

Following a successful 'Interim Assessment' and adequate training of approach controllers and participating pilots from the lead or nominated carrier(s), the provisional procedures should be implemented as a limited trial.

Once the trial is commenced, a continuous review of progress is undertaken in order to identify opportunities to improve performance, which should include suggestions from operational staff. Open reporting should be encouraged amongst all key members and appropriate feedback arrangements implemented to identify those flights in which a CD was commenced but terminated or modified.

Following a successful trial, CD is introduced commencing in periods of low traffic volume and is gradually extended both in terms of the number of carriers involved and the time period covered.

Adequate local guidance, training and promotional activities and materials are developed and applied to maximise the achievement of CD. This should be combined with regular feedback and reporting on CD compliance.